K30. PIR DETECTOR USING MOVEMENT IC & PCB MOUNTED LENS

Making a movement detector using a high-gain op-amp circuit has never been easy. It is interesting to see how magazine articles present the subject; they always imply that the project is easy. The problem is that as the gain of the circuit is increased the slightest line voltage luctuation will false trigger the unit. This arises when you try to run the op-amp circuit from the same power supply which operates the siren, or even an LED which comes on when the unit is triggered. It is still a black art to juggle the position of voltage regulators & special op-amps, capacitors & components to minimise this problem. So both for the hobbyist and commercial user there is a real attraction to have the movement detector circuit all contained in one IC. Heimann were first to put the complete electronics of a movement detector into one IC. But it was too expensive for commercial use and has been discontinued. The 20 pin DIP IC supplied here is the result of a recent American - Hong Kong Chinese venture to do the same thing more cheaply. Our tests on this IC show it to be very good & easy to use.

And the choice of an efficient lens system is also important. The purpose of the fresnel lens is to break up the area under observation into optical zones so that a heat source moving from one optical zone to another will generate a heat wave on the surface of the PIR detector. It is no use having an excellent electronic circuit if the IR optical system is not very good. A lower gain circuit with an excellent lens system is far better than an excellent circuit & poor lens system. (Many cheap commercial detectors follow this philosophy.) And herein lies the problem for the hobbyist: it has always been difficult for the hobbyist to construct a curved mounting to hold the large plastic-sheet Fresnel lenses which give the most sensitive IR optics onto the PIR sensor. The physics of a creeping burglar at 25 yards (or meters) simply demands a focal length of 4 to 5cm for the lens/sensor system in order for the motion to be reliably detected. The PCB-mounted lens supplied in this Kit is a good compromise. It will reliably detect motion in the 3 to 4 meters (yards) range.

The technology of PIR sensors is now well known and has been published in most hobby magazines sometime within the last 5 years. Dual sensor PIR detectors are now the most widely used motion detectors. The other technologies (mainly ultrasonic) suffer too much from false triggering or are too expensive.

The kit is constructed on a single-sided printed circuit board (PCB). It has a silk screen overlay on top to aid construction. On the bottom there is a solder mask to help in soldering.

ASSEMBLY

Before you do anything. The RE200B PIR (passive infra red) sensor, the LDR (light dependent resistor) and the plastic PCB-mounted Fresnel lens are all to be mounted on the **BACK**, copper side of the PCB. They do not go on the top of the PCB where all the other components go. This is so that the unit can be easily placed in a box with the lens poking out a hole in the box but with the electronics on the top of the PCB inside the box for easy access. Mount these 3 components last as described below.

Also consider at this time the position of the 2 LED's. You may want to put 1 or both of them also on the bottom of the PCB depending on how you want to use the Kit.

First Thing. Place all the components in a container and check them off against the Component list. Do not touch the surface of the PIR detector. It is generally easiest to solder the lowest height components first - the resistors, switches and IC socket. Make sure you get the electrolytic capacitors, the LED's and the diode in the correct way. For the LED's the short leg and the flat on the plastic case is the cathode and corresponds to the bar on the overlay. Do not mix up the 78L05 with the 2 BC547's. They all come in a TO-92 package. Note that C5 is a low-leakage electrolytic capacitor.

The three trimpots & 3 terminal blocks should be the last items to solder into placeon the top. Now we will describe how best to assemble the LDR and PIR sensor.

LDR, Lens & PIR Sensor. These 3 components go on the copper side - the bottom side - of the PCB. First the LDR. Put it through the two holes from the copper side and support it about 1/8" to 1/4" (4 to 8 mm) above the surface. Solder it into place. Cut off the legs.

PIR. This also is mounted on the copper side. The top overlay gives an X-ray view of how to mount it. The 3 legs can only fit into the PCB one way from the bottom so there should not be a problem. The notch on the sensor should be directly underneath the notch as printed on the overlay. Now unlike the LDR the 3 legs have to be spread out on the top of the PCB and inserted into their espective holes & soldered. Follow the link tracks: D-D, G-G, S-S.

Lens. Finally the plastic lens should be snapped into place on the bottom side to cover the sensor & LDR.

CIRCUIT DESCRIPTION

Important Note. Due to the sensitive electronics in the movement IC and the PIR sensor there is a warm-up period of about a minute required when you turn the detector on before it will work. Also changes to settings (in particular the daylight level) require about 90 seconds to take effect. Remember that the fast digital world does not apply to these modern analog devices.

The heart of the circuit is the motion detection IC. Electrical signals from the PIR sensor have a very low frequency (0.1 to 10Hz) and bandwidth. The IC is optimised for this. The operating voltage of the KC778B itself is 4 - 15V. But with the 78L05 regulator voltage input should be in the 9V to 12V range. There are three sensitivity controls built into the circuit. They can be seen in the schematic diagram on the next page.

- sensitivity is controlled at pin 2 by trimpot P1. When this pin equals the sensor drain potential at pin 7 (about 0.5V) sensitivity is at a minimum.

When pin 2 is connected to ground (about 0.125V) sensitivity is at a maximum.

- daylight sensitivity using trimpot P2 and the LDR. Maybe you want the sensor to be inactive during the daytime and only active at night. (For example, if it is connected to a night light.) If you do not want this feature then tie pin 12 to Vcc and leave pin 11 unconnected.

- pulse on-time trimpot P3. This adjusts the output pulse from between 1.5 seconds upwards. For the minimum time delay you can directly connect pins 18 & 19 with no external capacitor or resistor. The output signal turns on LED2 and the signal is available from the Output terminal block to be connected to any device you choose - bell, buzzer, siren, relay etc. A protection diode D1 has been placed across the output to short circuit any back emf from relays connected across the Output.

Pin 17 is also connected to an LED, LED1. This IC output always goes on when the sensor & IC detect movement. But this trigger may result in an Output signal. For example, when the Output from the unit is off during the daytime. Also there is an inbuilt latency period of about 1.5 seconds in the Output pulse when triggered. This latency period is essential to smooth out the multiple trigger pulses actually sensed by the detector (as shown by LED1.) LED1 can of course be removed if it is not wanted. There is an internal 500R resistor on pin 17 so a current limiting resistor is not required.

Exit Delay. The Toggle terminal Block has been configured to give the user an exit delay of about 30 seconds in which time the detector will not operate. This can be used to test that the detector is working or give you time to leave the room after you have turned it on. See pin 15 below.

Further Pin Details

Pin 3 Offset Filter. Connects to an external 10uF capacitor & holds the average value of the switched capacitor bypass filter output. Motion is detected when the difference between this average and the actual filter output is greater than the sensitivity setting.

Pin 4 Anti-Alias. Connects to external 0.1uF providing low-pass filtering of the PIR signal input signal blocking input signals at and above the switching frequency of the switched capacitor bypass filter.

Pin 5 DC Cap. Connects to an external 10uF and holds the average source potential. The difference between this average & the actual source potential is amplified & coupled to the switched capacitor bypass filter. It should be a low-leakage or tantalum capacitor.

Pin 6 Vreg. This is supposed to be a voltage regulator pin. However, we found it did not work as advertised & we used an external voltage regulator.

Pin 7 Drain Reference. The potential is power supply independent. The potential can be divided down by an external pot to supply the sensitivity adjust to pin 2.

Pin 8 Source. PIR input. It is sensitive and should be as short a length as possible. There should be a ground plane on the PCB under the sensor.

Pin 9 is Analog ground and Pin 10 is Digital Ground

Pin 13 Gain Select. When unconnected gain is 68db. When connected to ground gain is 62db. We have left it unconnected here.

Pin 14 On/Auto/Off. Unconnected the IC works automatically. Connected to ground the IC will turn off unconditionally. Connected to Vcc it will turn on unconditionally.

Pin 15 Toggle. Unconnected the IC works automatically. Connected to ground the IC state will turn change its state and remain in the new state unconditionally as long as the pin is connected to ground. We have configured this feature to give a delay. If there is a conflict between pins 14 & 15 the off state is the default.

Pin 16 Output. Can direct drive triac, optocoupler or small relay. Output impedence is 35R allowing it to direct drive a small (100R coil resistance) relay.

Pin 20 Frequency Reference. 160Hz is used to drive the internally switched capacitor, bandpass filter & timing delays. It is connected externally through a 60K resistor to Vcc and a 0.1uF capacitor to Gnd.

There are more specifications at
http://www.kitsrus.com/gif/comic_p1.gif
http://www.kitsrus.com/gif/comic_p1.gif

PIR Sensor. The dual element PIR detector RE200B from Nippon Ceramic has a field of view from 125^{o} to 138^{o} (axis dependent.) It has greater than 70% transmission in the infra-red 700 to 1400 nm range. Each element generates a DC voltage proportional to the heat 'seen'. The two elements are connected in series opposition so that any common input is cancelled out. This is important for two reasons; it makes the sensor immune to changes in ambient temperature. Second, it allows the differential signal to be greatly amplified. Operating voltage from 3-10V.

There are some specifications at
http://www.kitsrus.com/ jpg/pir_1.jpg
http://www.kitsrus.com/ jpg/pir_2.jpg

LDR spec see: http://www.kitsrus.com/projects/cds.pdf

Fresnel Lens spec see:
http://www.kitsrus.com/ projects/fresnel.pdf

WHAT TO DO IF IT DOES NOT WORK

Did you remember to allow about a minute for the Kit to warm-up before it will work. Poor soldering is the most

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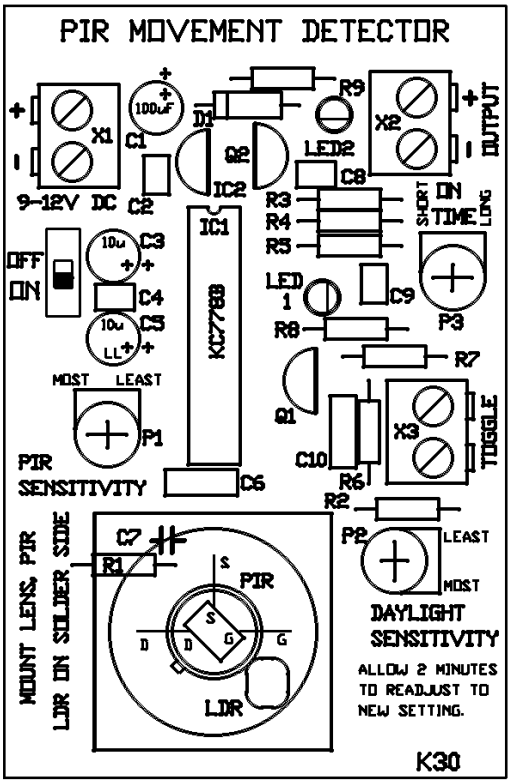
likely reason that the circuit does not work. Check all solder joints carefully under a good light. Next check that all components are in their correct position on the PCB. Check especially the orientation of the LEDs, electrolytic capacitors, transistors, voltage regulator and the IC. Are the PIR sensor & LDR on the bottom of the board?



COMPONENTS

Resistors 5% carbon film:		
1K brown black red	R8 R9	2
3K9 orange white red	R3	1
10K brown black orange	R2 R5 R7	3
47K yellow violet orange	R1 R6	2
56K green blue orange	R4 1	
200K Koa trimpot 204	P1 P2	2
1M Koa trimpot 105	P3	1
10uF mini elcap	C3	1
10uF Low leakage elcap	C5	1
100uF mini elcap	C1	1
100nF monoblock 104	C2 C4 C6 C8	4
220pF ceramic 221	C7	1
4n7 ceramic 472	C9	1
470nF monoblock	C10	1
KC778B Movement	IC1	1
20 pin IC socket		1
BC547 transistor	Q1 Q2	2
78L05	IC2	1
1N4004 diode	D1	1
2 pole terminal blocks		3
3mm LED		2
RE200B PIR sensor		1
Light Dependent Resistor LDR		1
PCB-mounted Fresnel Lens		1
Kit 30 PCB		1
SPDT PCB-mounted switch		1